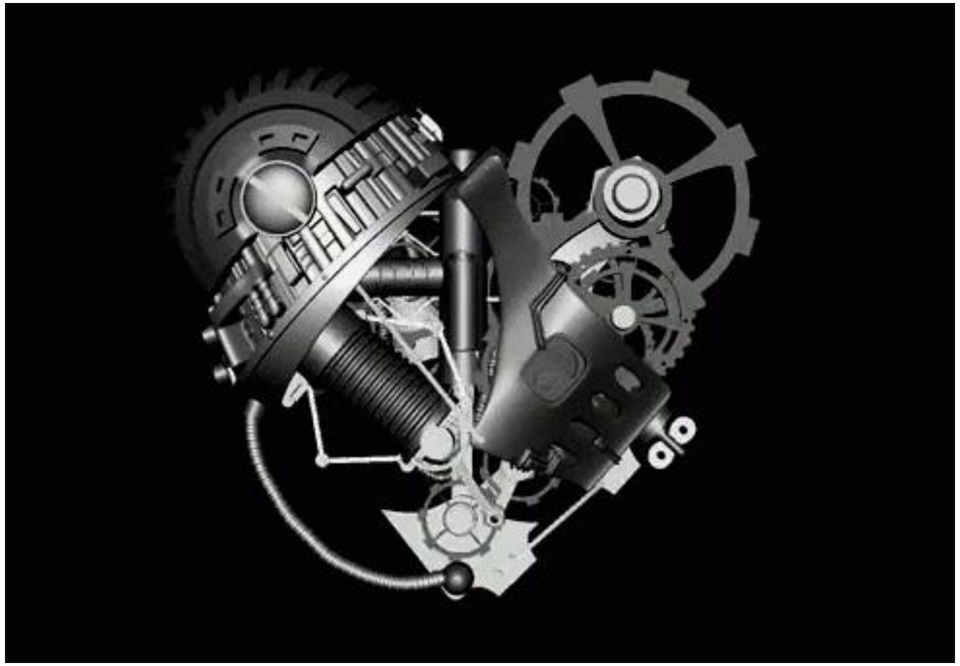
Grade 12 – Physics



Unit 1: Mechanics

Chapter 1: Energy

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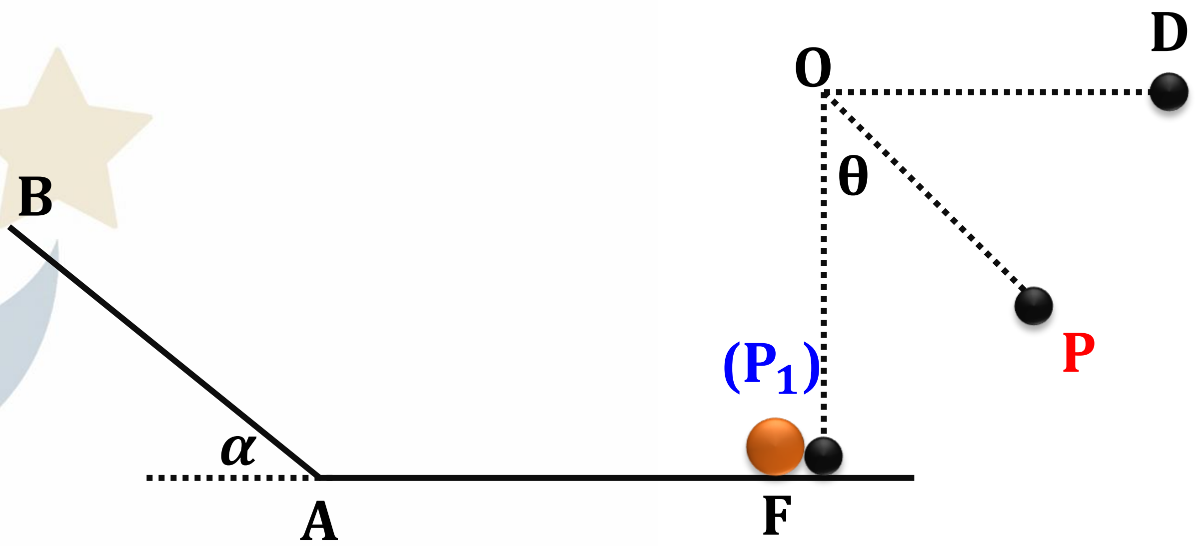
Quiz
Time

Quiz 1: **Energy** **20 min**

Consider pendulum is formed of an inextensible and mass less string of length $l = 0.45m$ having one of its ends fixed while the other end carries a particle (P) of mass 100g. $g = 10m/s^2$.



The pendulum is shifted from its equilibrium position by $\theta_m = 90^\circ$, then released without initial velocity.

Take the horizontal plane containing FA as a gravitational potential energy reference for the system [(S), Earth].

We neglect friction on the axis through O and air resistance.

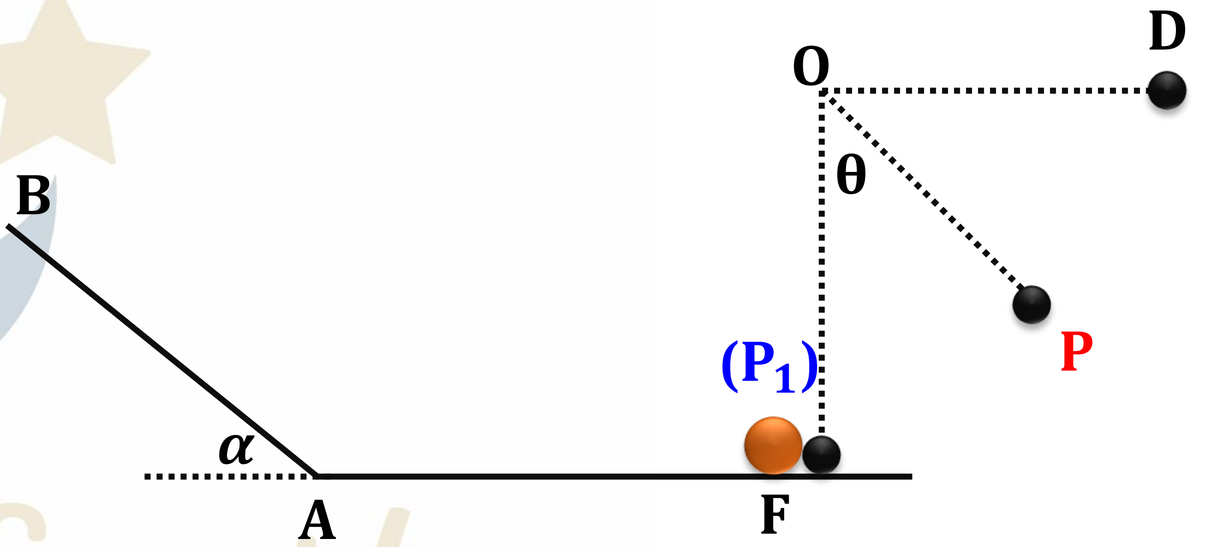
Quiz 1 **Energy** **20 min**

1. **Calculate the initial mechanical energy of the system [(S),Earth] when (P) was at D.**
2. **Determine the expression of the mechanical energy of the system [(S),Earth] in terms of l, m, g, V and θ, where v is the speed of (P) when the string passes through a position making an angle θ with the vertical.**
3. **Determine the value of θ, $(0 < \theta < 90^{\circ})$, for which the kinetic energy of (P) is equal to the gravitational potential energy of the system [(S),Earth].**
4. **Calculate the magnitude of the velocity V_0 of (P) as it passes through its equilibrium position.**

Quiz 1: Energy 20 min

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

1. Calculate the initial mechanical energy of the system [(S),Earth] when (P) was at D.



$$ME_D = KE_D + PE_D \Rightarrow ME_D = \frac{1}{2}mV_D^2 + mgh_D$$

$$ME_D = \frac{1}{2}(0.1)(0)^2 + 0.1 \times 10 \times l(1 - cos\theta)$$

$$ME_D = 0 + 0.1 \times 10 \times 0.45(1 - cos90^\circ) \Rightarrow ME_D = 0.45J$$

Quiz 1: **Energy** **20 min**

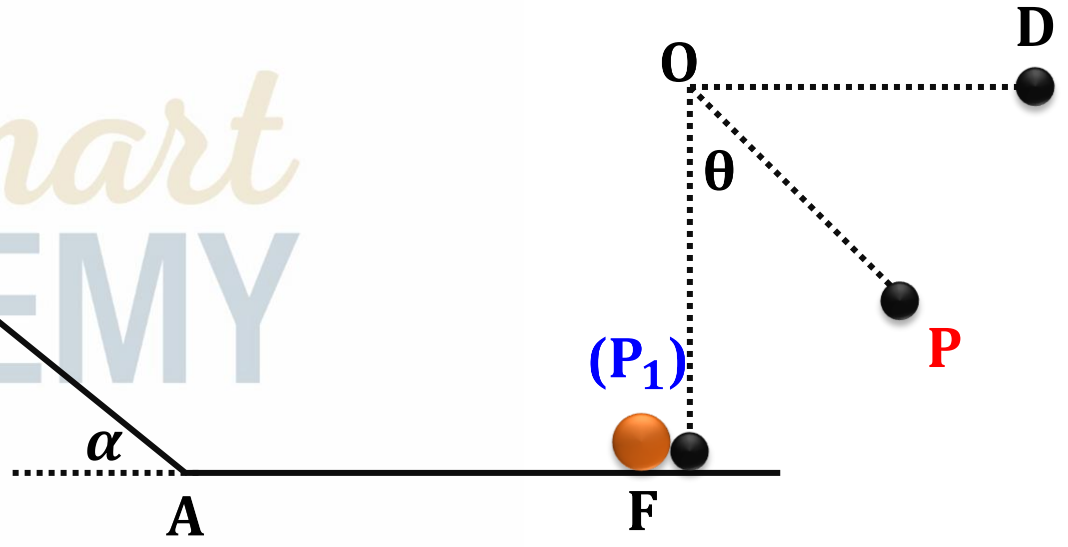
$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^{\circ}$, $V_D = 0m/s$; $f = 0N$

2.Determine the expression of the ME of the system [(S),Earth] in terms of l, m, g, V and θ, where v is the speed of (P) when the string making an angle θ with the vertical.

$$ME = KE + PE$$

$$ME = \frac{1}{2}mV^2 + mgh$$

$$ME = \frac{1}{2}mV^2 + mgl(1 - cos\theta)$$



Quiz 1: Energy 20 min

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

3.Determine the value of θ, $(0 < \theta < 90^\circ)$, for which the kinetic energy of (P) is equal to the gravitational potential energy of the system [(S),Earth].

The ME is conserved, because friction is neglected; then:

$ME = ME_D$ ⇨ $KE + PE = 0.45J$

But given $KE = PE$ then:

$PE + PE = 0.45J$

$2PE = 0.45J$

$2mgl(1 - \cos\theta) = 0.45J$

$2 \times 0.1 \times 10 \times 0.45(1 - \cos\theta) = 0.45J$

$\cos\theta = 0.5$ ⇨ $\theta = 60^\circ$

Quiz 1: **Energy** **20 min**

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

4.Calculate the magnitude of the velocity V_0 of (P) as it passes through its equilibrium position

$$ME_O = KE_O + GPE_O$$

$$0.45J = \frac{1}{2}mV_0^2 + mgh_0$$

$$0.45J = 0.5 \times 0.1V_0^2 + 0.1 \times 10(0)$$

$$0.45J = 0.05V_0^2$$

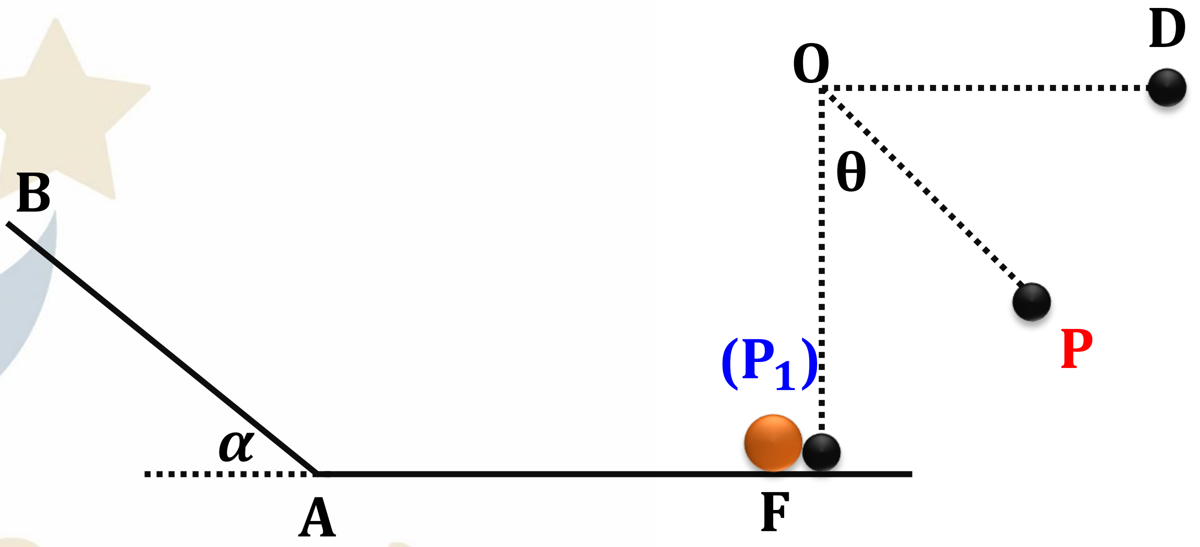
$$V_0^2 = \frac{0.45}{0.05}$$

$$V_0^2 = 9$$

$$V_0 = 3m/s$$

Quiz | Energy | 20 min

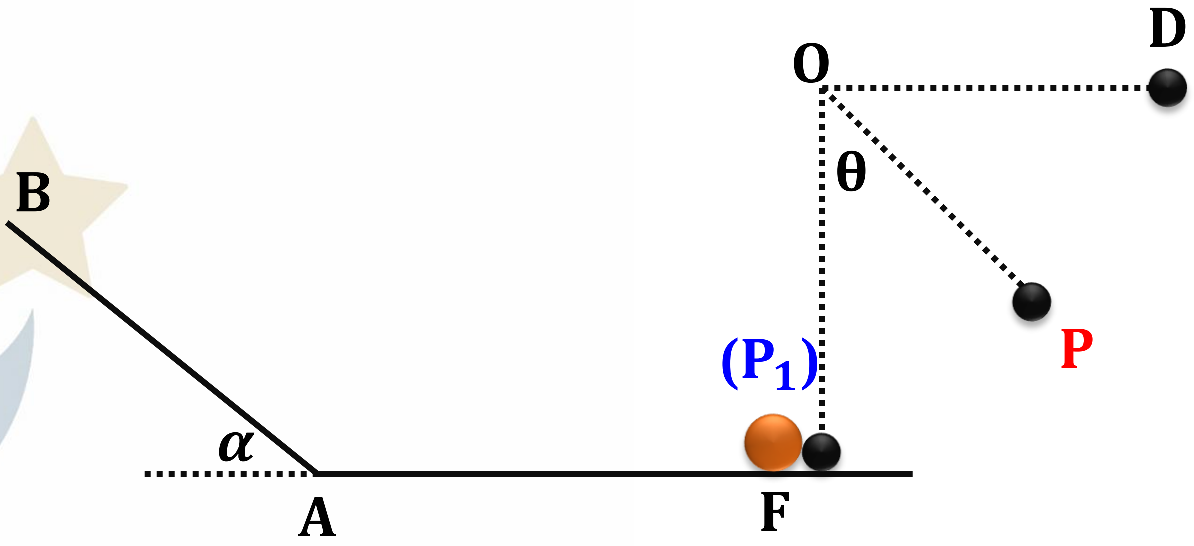
When (P) passes through the equilibrium position, the string is cut, and (P) enters in a collision with a stationary particle (P_1) of mass $m_1 = 200g$.



As a result of collision (P_1) moves along the frictionless horizontal track FA and reaches A with the speed $V_1 = 2m/s$.
(P_1) continues along the line of greatest slope of the inclined frictionless plane AB that makes an angle $\alpha = 30^{\circ}$ with the horizontal.

a. Determine the altitude of the point M between A and B at which (P_1) turns back.

b. In fact, AB is not frictionless, (P_1) reaches a point N and turns back, where AN = 20 cm.

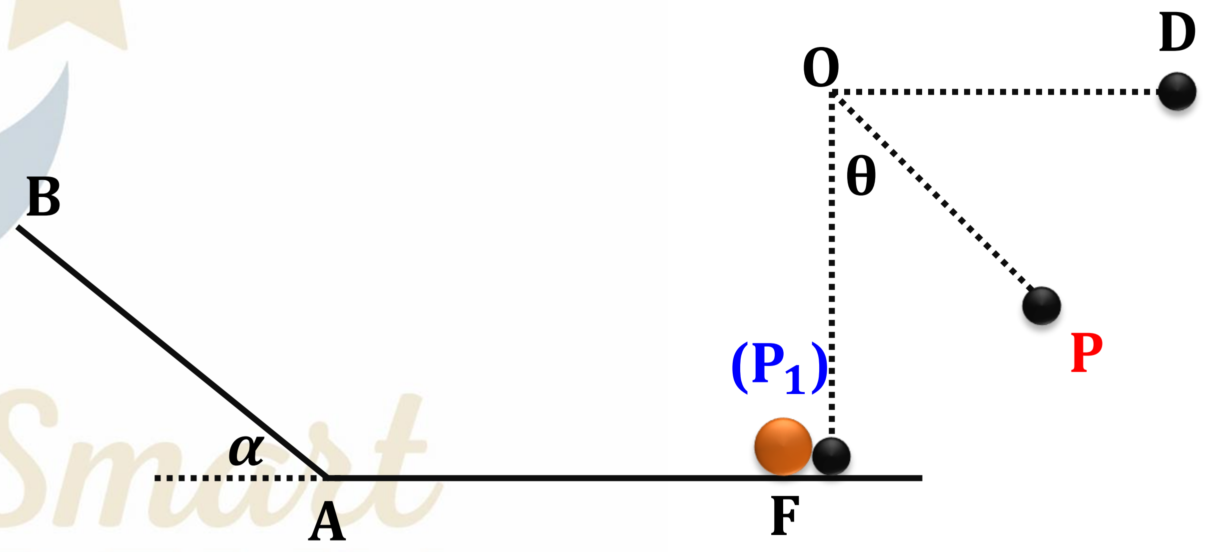


Calculate the magnitude of the force of friction (assumed constant) along AN.

Quiz 1: **Energy** **20 min**

$m_1 = 0.2kg; g = 10m/s^2; f = 0N; V_1 = 2m/s; \alpha = 30^\circ$

a)Determine the altitude of the point M between A and B at which (P_1) turns back.



At point M the particle (P_1) returns then: $V_M = 0$

$$ME_A = ME_M$$

$$KE_A + PE_A = KE_M + PE_M$$

$$\frac{1}{2}mV_A^2 + mgh_A = \frac{1}{2}mV_M^2 + mgh_M$$

Quiz 1: **Energy** **20 min**

$$\frac{1}{2}m_1V_A^2 + m_1gh_A = \frac{1}{2}m_1V_M^2 + m_1gh_M$$

$$0.5 \times 0.2 \times (2)^2 + 0.2 \times 10 \times (0) = 0.5 \times 0.2(0)^2 + 0.2 \times 10h_M$$

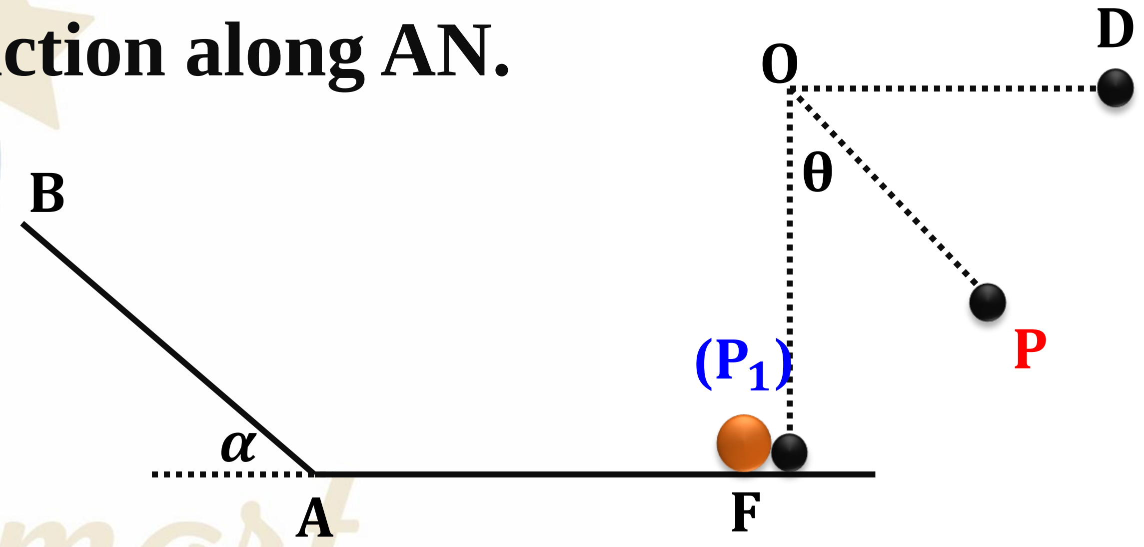
$$0.4 = 2h_M \quad \Rightarrow \quad h_M = \frac{0.4}{2}$$

$$h_M = 0.2m$$

Quiz 1: Energy 20 min

b) In fact, AB is not frictionless, (P_1) reaches a point N and turns back, where $AN = 20cm$.

Calculate the magnitude of the force of friction along AN.



$$ME_N = KE_N + PE_N$$

$$ME_N = 0 + mgh_N$$

$$ME_N = 0 + mgANsin\alpha$$

$$sin\alpha = \frac{opp}{hyp} = \frac{h_N}{AN}$$

$$ME_N = 0.2 \times 10 \times 0.2sin30 = 0.2J$$

$$h_N = ANsin\alpha$$

$$\Delta ME_{A\to N} = W_{\overrightarrow{fr}}$$

$$ME_N - ME_A = -f \times AN$$

$$0.2 - 0.4J = -f \times 0.2$$

$$-0.2J = -f_r \times 0.2$$

$$f_r = 1N$$


Quiz
Time

Quiz 2 **Energy** **20 min**

A particle of mass m = 0.2kg is launched at $t_0 = 0$, from the ground vertically upward with an initial speed v_0. Take the ground as a level for gravitational potential energy reference. Use $g = 10m / s^2$

1. Motion without air resistance:

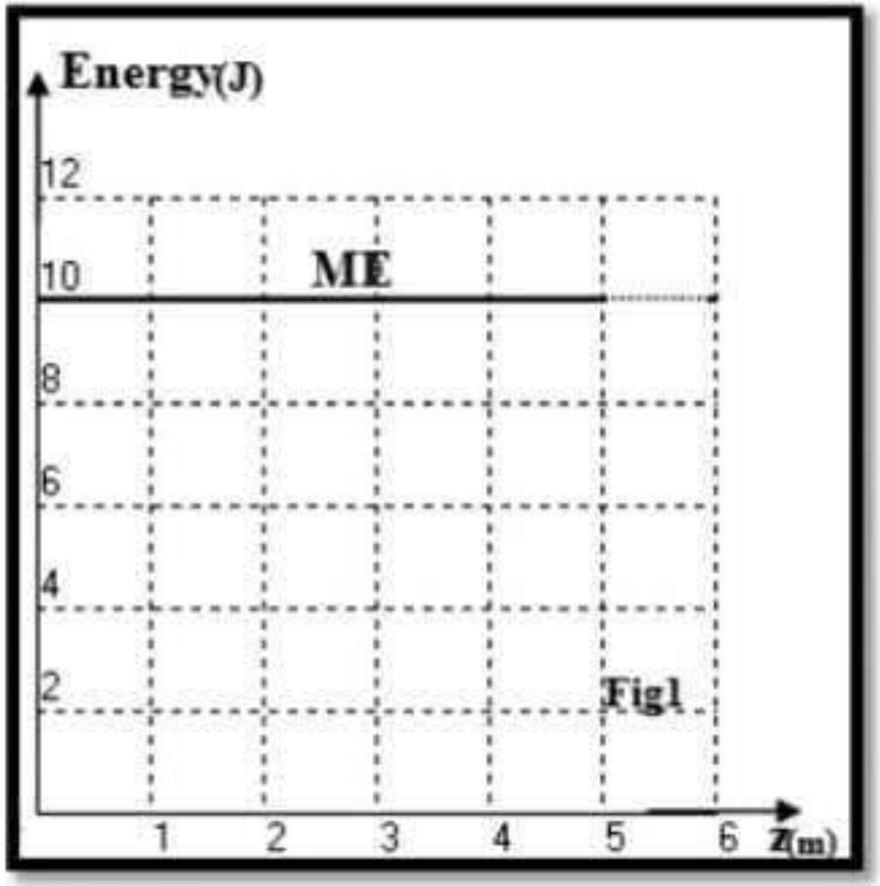


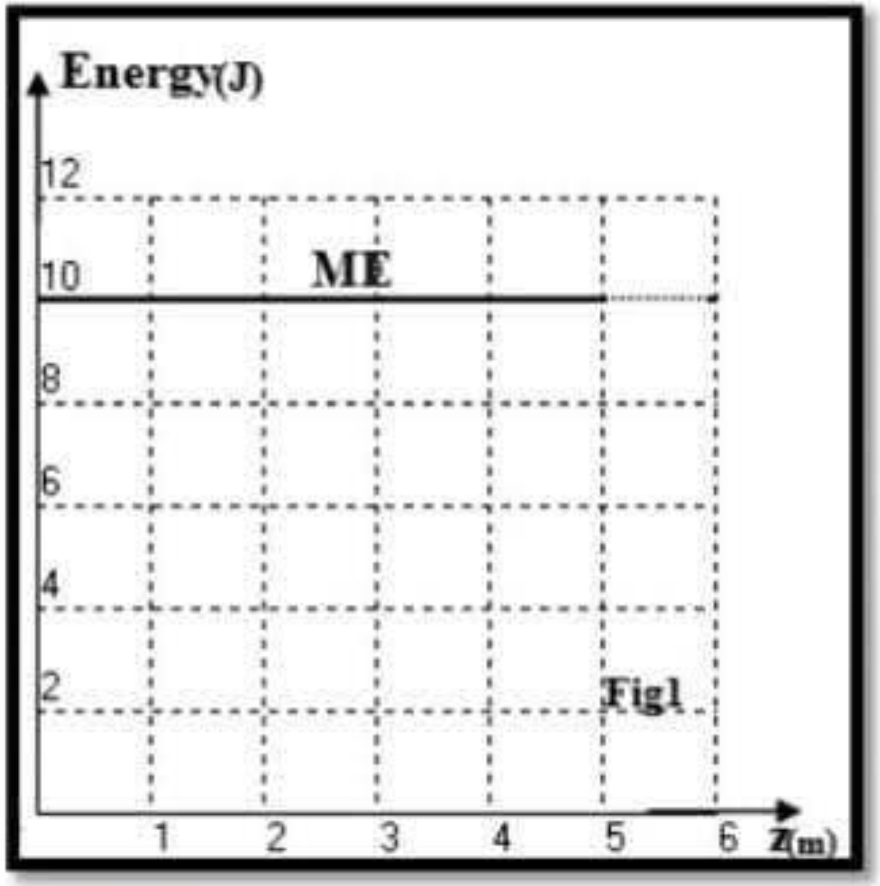
Figure 1 shows the variation of the mechanical energy of the system (Particle; Earth;) as a function of the height z during the ascending phase.

1.1.Use the figure to show that, there are no resistive forces.

1.2.Determine the initial speed v_0.

1.3. Write the expression of the GPE as a function of the height z, and then draw on the same given figure the graph that represents the variation of the GPE as a function of z.

1.4.Draw on the same given figure the graph that represents the variation of the kinetic energy of the particle.



1.5.Deduce, graphically, the maximum height Z_{max} reached by the particle.

Quiz 2 — Energy — 20 min

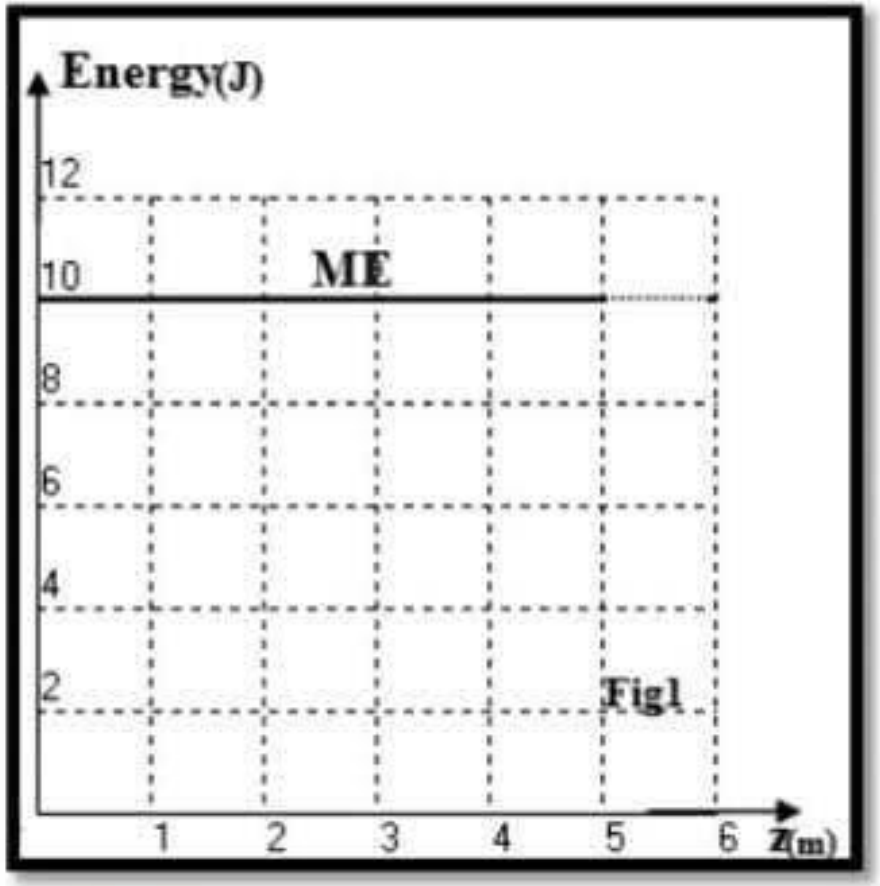
m = 0.2kg; v_0 =?; $g = 10m / s^2$

1. Motion without air resistance:

1.1.Use the figure to show that, there are no resistive forces.

Since the ME is constant at ME=10J; then the ME is conserved.

Therfore, the resistive force is not exist



1.2.Determine the initial speed v_0.

$ME_0 = GPE + KE$ ➡ $ME_0 = mgh + 1/2mv_0^2$

$$10 = 0.2 \times 10 \times (0) + 1/2 \times 0.2v_0^2$$

$10 = 0.1v_0^2$ ➡ $v_0^2 = \frac{10}{0.1} = 100$ ➡ $v_0 = \sqrt{100} = 10m/s$

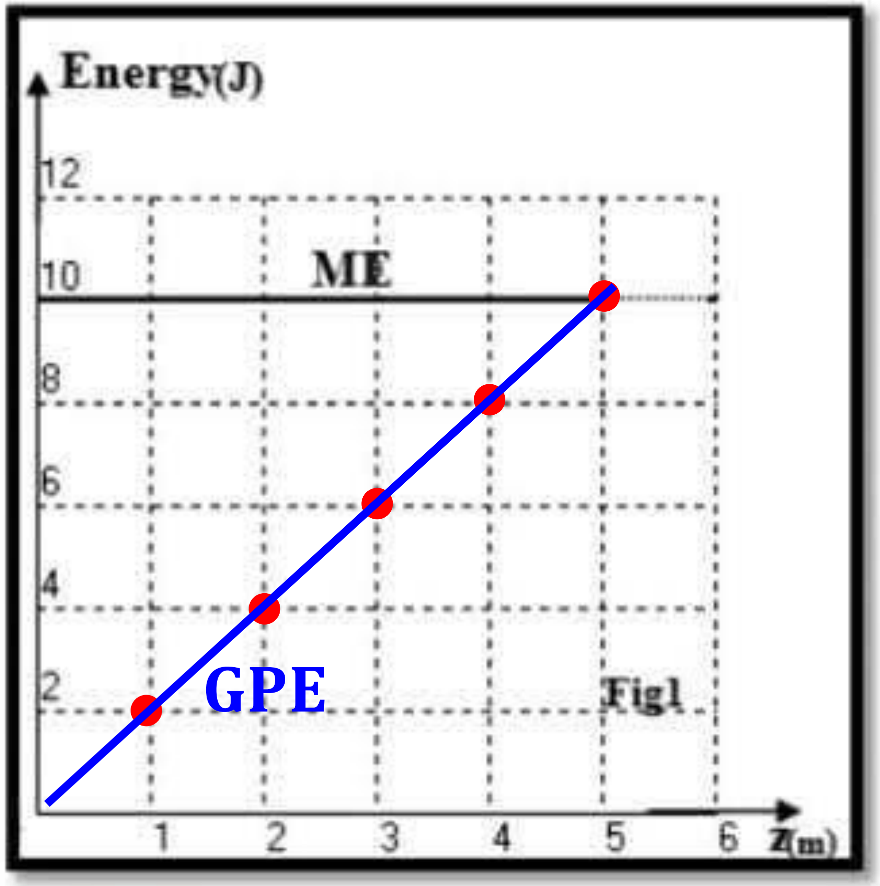
1.3. Write the expression of the GPE as a function of the height z, and then draw on the same given figure the graph that represents the variation of the GPE as a function of z.

$$GPE = mgh$$

$$GPE = 0.2 \times 10 \times z$$

$$GPE = 2z$$

Z	1	2	3	4	5
$GPE = 2z$	2	4	6	8	10

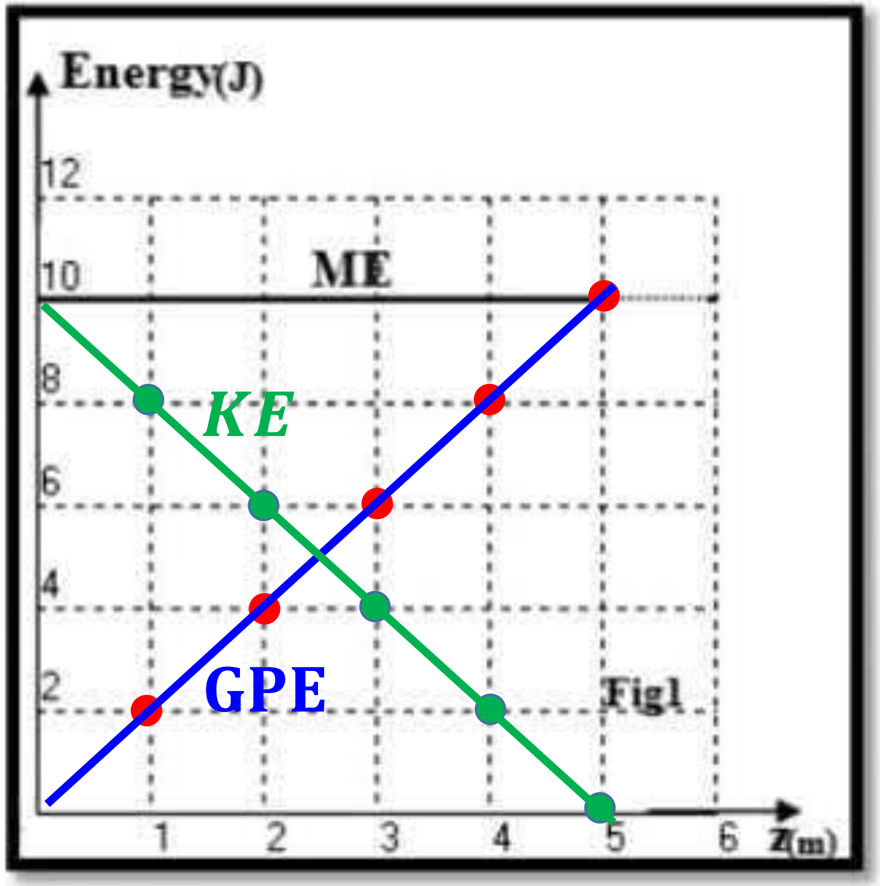


1.4.Draw on the same given figure the graph that represents the variation of the kinetic energy of the particle.

$$ME = GPE + KE$$

$$10 - GPE = KE$$

Z	1	2	3	4	5
GPE = 2z	2	4	6	8	10
KE	8	6	4	2	0

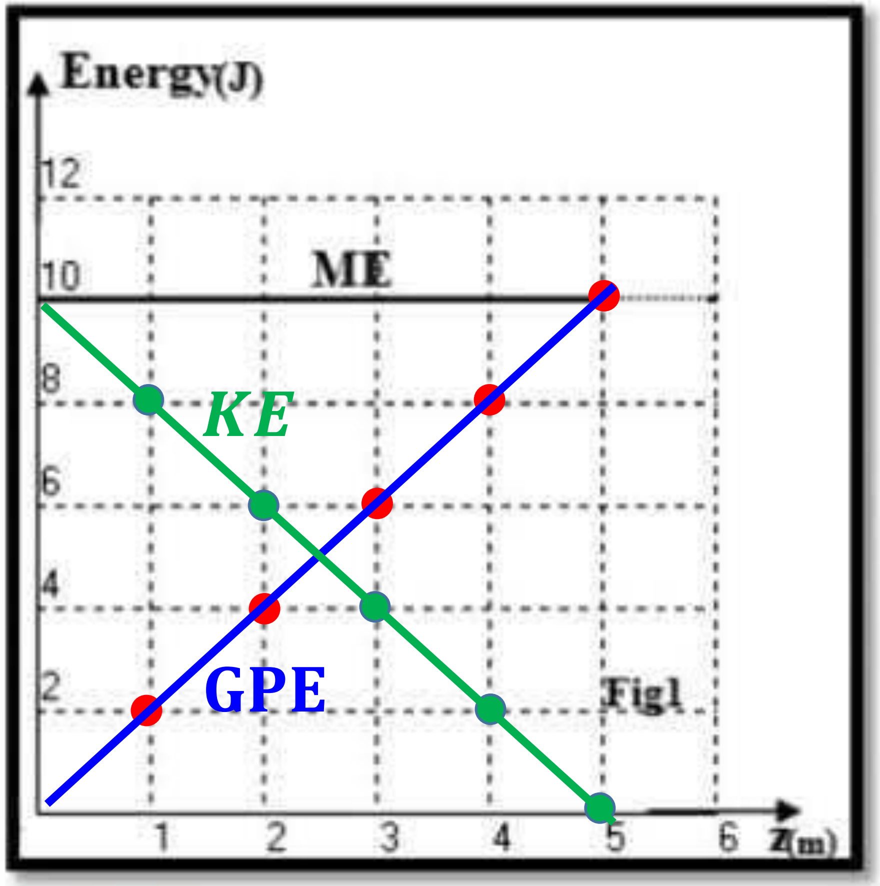


1.5.Deduce, graphically, the maximum height Z_{max} reached by the particle.

At the maximum height Z_{max} reached by the particle; the speed become zero (v=0).

Therfore, KE=0J.

From the graph, KE=0J at Z=5m



Quiz 2 **Energy** **20 min**

Motion with air resistance:

The particle is subjected to air resistance whose direction is opposite to the velocity v of the particle and whose magnitude is $f = 0.5N$.

The adjacent figure (2) represents the variations of the kinetic of the particle as a function of the height z, during the ascending of the particle.

2.1.Determine the expression of the kinetic energy of the particle as function of z.

2.2.Show that the expression of the mechanical energy of the system is $ME = -0.5z + 10$

2.3.Determine the maximum height reached by the particle.

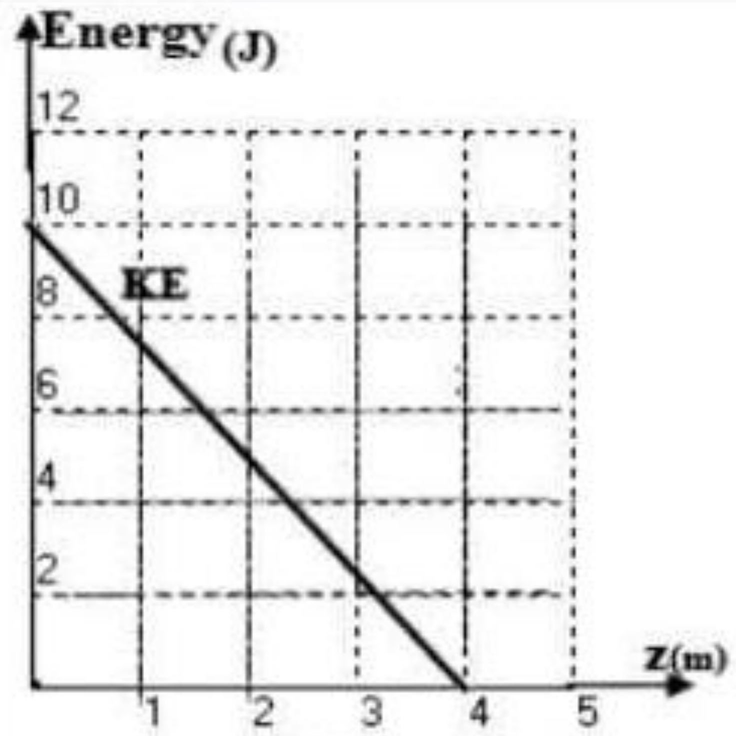


Fig 2

2.4.Show that at any instant t the relation between the algebraic value v of the velocity of the particle and its altitude z above the ground is: $0.1v^2 + 2.5z = 10$

2.5.Deduce the algebraic value of the acceleration of the particle.

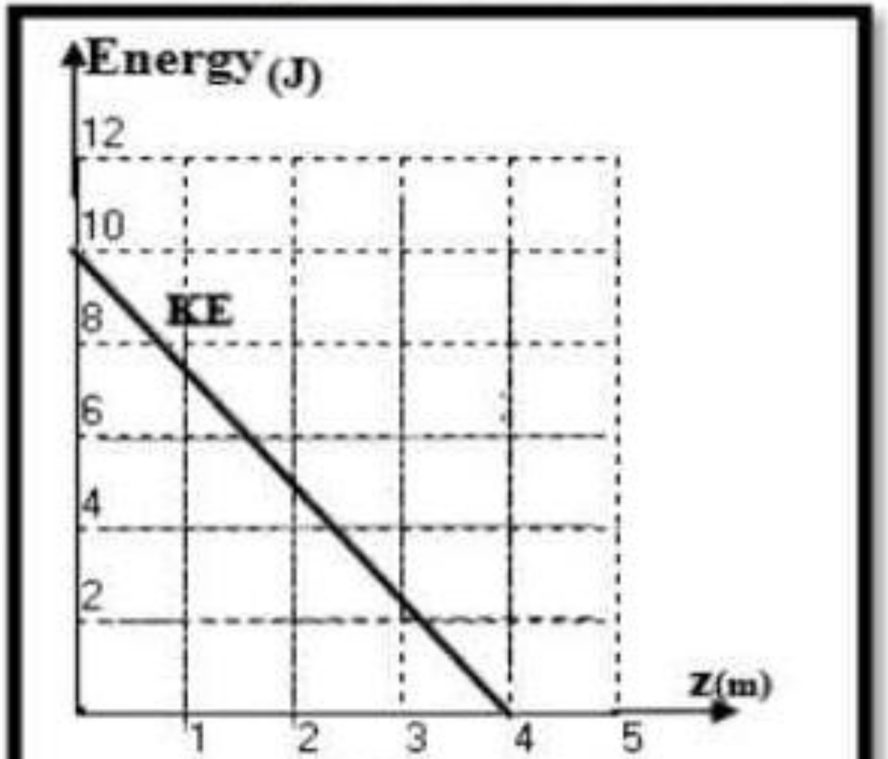


Fig 2

2.1. Determine the expression of the kinetic energy of the particle as function of z.

The graph of KE is S.t line of general equation:

$$KE = az + b$$

$$a = slope = \frac{KE_2 - KE_1}{Z_2 - Z_1} = \frac{10 - 0}{0 - 4} = -2.5$$

The constant b is the y-intercept:

$$b = 10$$

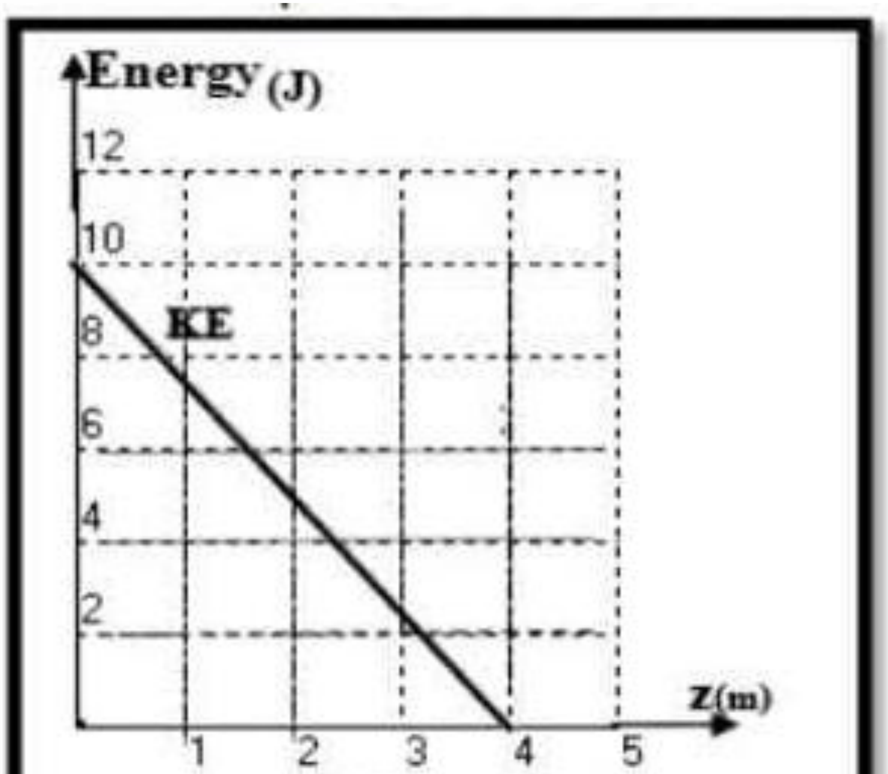


Fig 2

$$KE = az + b$$

$$KE = -2.5z + 10$$

2.2.Show that the expression of the mechanical energy of the system is $ME = -0.5z + 10$

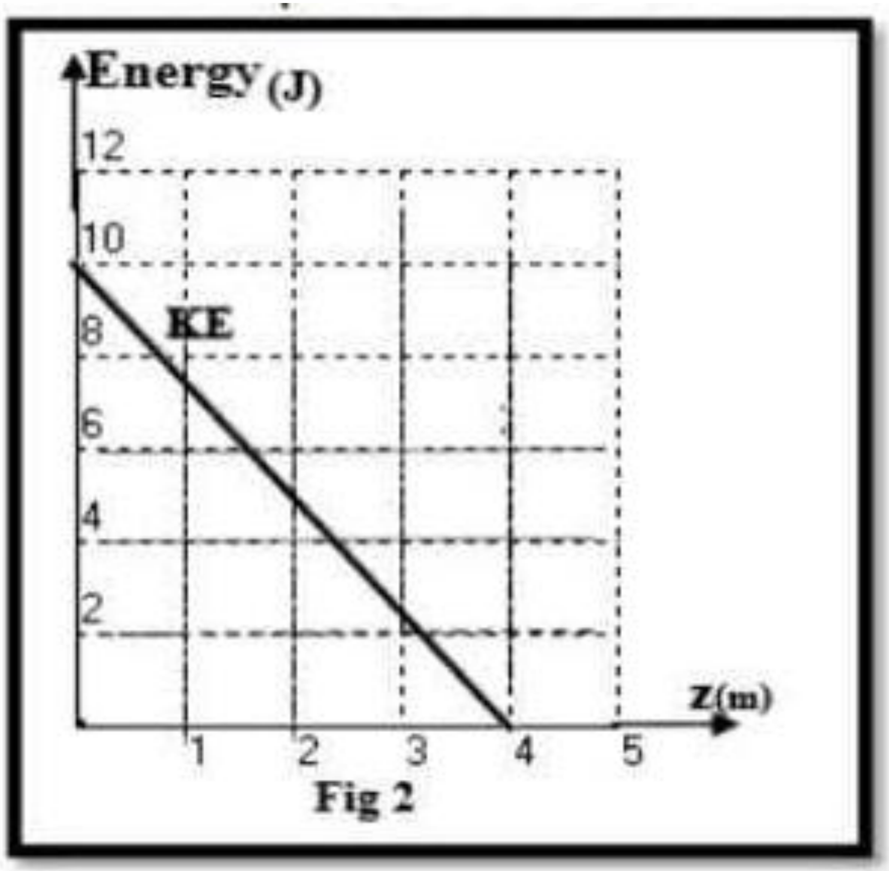


Fig 2

$$\mathrm{ME} = \mathrm{GPE} + \mathrm{KE} \Rightarrow \mathrm{ME} = \mathrm{mgh} + -2.5z + 10$$

$$\mathrm{ME} = 0.2 \times 10\mathrm{z} + -2.5z + 10$$

$$\mathrm{ME} = 2\mathrm{z} + -2.5z + 10$$

$$\mathrm{ME} = -0.5z + 10$$

2.3.Determine the maximum height reached by the particle.

At the maximum height Z_{max} reached by the particle; the speed become zero (v=0).

Therfore, KE=0J. **From the graph, KE=0J at Z=4m**

Quiz 2 **Energy** **20 min**

2.4.Show that at any instant t the relation between the algebraic value v of the velocity of the particle and its altitude z above the ground is: $0.1v^2 + 2.5z = 10$

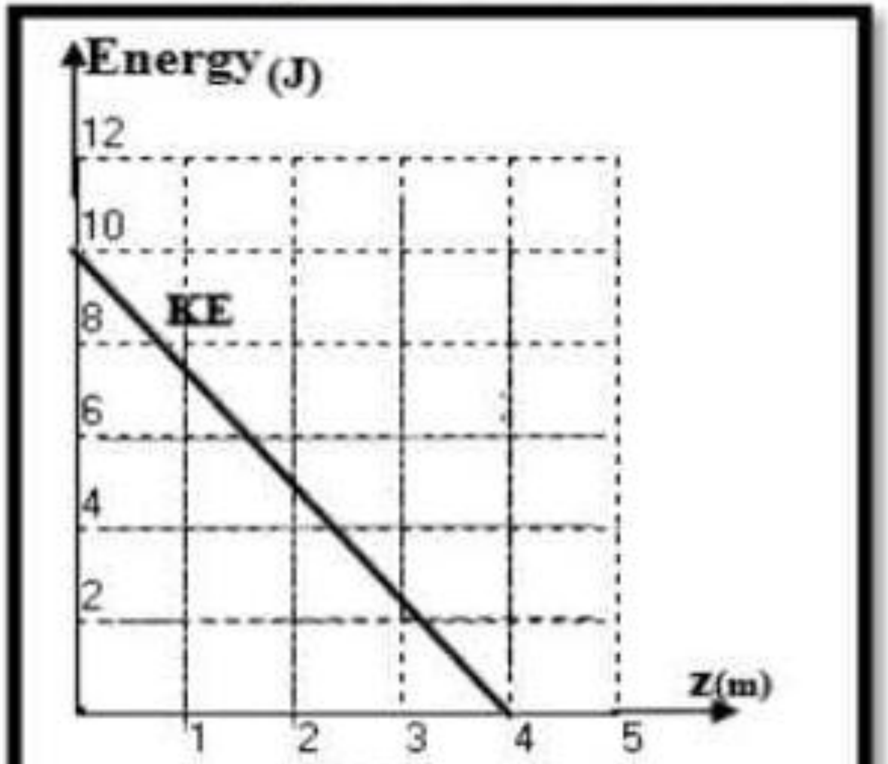


Fig 2

$\mathbf{ME = GPE + KE}$ → $\mathbf{ME = 1/2mv^2 + mgh}$

$$-0.5z + 10 = \frac{1}{2} \times 0.2v^2 + 0.2 \times 10 \times z$$

$$-0.5z + 10 = 0.1v^2 + 2z$$

$$10 = 0.1v^2 + 2z + 0.5z$$

$$10 = 0.1v^2 + 2.5z$$

2.5.Deduce the algebraic value of the acceleration of the particle.

$$10 = 0.1v^2 + 2.5z$$

Derive the above expression w.r.t

$$0 = 0.1[2v.v'] + 2.5.v$$

$$0 = 0.1[2v.v'] + 2.5.v \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\div v)$$

$$0 = 0.22.a + 2.5$$

$$0.22.a = -2.5$$

$$a = \frac{-2.5}{0.22} = -11.36m/s^2$$


A Very Special
"Thank You!"